ECE 403

Senior Design II

Conceptual Design and Options Considered with Budget and Timeline

9/29/12

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Introduction:

The novel automobile safety system will explore the applications of using a sensor and a radio frequency (RF) system to keep the driver of an automobile safe. In the US and around the world there are many accidents that happen near or around stop signs. There are many reasons why accidents happen there, but a large reason is because drivers do not see the stop sign. Our project is aimed to fix this problem, by having a system that alerts drivers when they are approaching stop signs. Our present client is Dr. Bei Gou of the North Dakota State University Electrical Engineering Department.

Previous Work:

There are several existing products that are similar to the safety stop sign we are planning to produce. The existing products, though, do not have any features related to transmitting information to the oncoming traffic. We have researched the existing products to find ideas and design options for our project. The following is some information on the similar existing products:

BlinkerSign® Solar Flashing LED Traffic Sign: R1-1 Stop Sign

The BlinkerSign R1-1 Stop Sign is produced by Traffic and Parking Control Co., INC. (TAPCO). It features a stop sign with eight 1-watt LEDs powered by a battery and a solar panel. The sign has several “Smart Activation Options”: 24/7 continuous, time clock activation, wireless activation, and a vehicle detection activation. The R1-1 has two batteries that allows it to run in 24/7 continuous operation for up to 30 days. The cost to buy a R1-1 stop sign from TAPCO is around $1600.

The BlinkerSign R1-1 Stop Sign uses several patents. The patents we could find that it uses are #6,943,698 and #6,693,556. Those patents are for an “Enhanced Visibility Traffic Signal”. As far as we could tell, there was no information in these two patents on how a vehicle’s presence was sensed or the product’s activation options.

Similar to this product, we intend on having a battery and solar panel power everything. Also, our product will have the vehicle detection activation option built in. The main difference is that our product will also incorporate a transmitter and receiver system to alert drivers of the upcoming stop sign.

Solar Stop Sign

The Solar Stop Sign is produced by Lumastrobe. It also features a stop sign with eight 1-watt LEDs powered by a battery and a solar panel. The sign only has two options for operating times; a 24/7 continuous and a dusk to dawn option. It is very similar to the TAPCO R1-1 stop sign, just with a few differences, such as a different battery, fewer activation options, and shorter battery life (without recharge due to only having a single battery). The cost to buy this sign is $1375.

There were a couple ideas we got from the Solar Stop Sign. First, we are planning on only using a single battery to save on money and for a simpler design. Second, we would like to have our product be simple and have an economical design, and the sign from Lumastrobe is cheaper and has a much simpler design than the sign from TAPCO.

Traffic Speed and Data Storage:

There are many sensors traffic systems that measure speed and count vehicles, but they don't always save the data, they use it for some other purpose.

The Apollo counter/classifier, produced by Diamond Traffic Products, is one example of a traffic system used to save data about vehicles. It can store data for over 2 million vehicles and is powered by a solar panel. It is also portable. It has an operating temperature range of -40F to 160F, making it possible to use in many different parts of the world, in many different weather conditions.

Design Options:

This project incorporates a motion/speed sensor and multiple LED arrays to warn drivers when another vehicle is approaching a stop sign intersection. Our goal is to make this system fully operational, reasonably priced, and easily implemented into the current vehicle market. After brainstorming and discussing our ideas, we now have a general idea of how we want to reach our goals for this project. We now need to decide on the specific means with which we plan to do so.

Battery Power

Because stop signs are not always near a power source, we immediately decided that our LED/transmitter systems would need to be battery powered. However, we need to be careful about the type of battery we choose. Depending on where this (Stop Sign Sensor Array) will be deployed, our battery may need to be able to withstand a wide range of temperatures. We have also decided on recharging the batteries using a solar panel, meaning the battery we choose should be rated with a high amount of life cycles. In any case, the battery needs to be chosen with careful consideration, as the efficiency of our battery will affect the usefulness and practicality of our final product.

Li-Ion (Lithium Ion) Battery

Advantages

- High performance in colder weather (down to about 0 degrees Fahrenheit)
- Lighter weight compared to NiMH or NiCad batteries
- Rapid recharge rate

Disadvantages

- Occasionally will erupt or explode when exposed to high heat
- Permanent damage to battery if it is stored at too-low discharge levels
- May potentially melt and leak lithium-containing liquid if tampered with or left in direct sunlight

NiCad (Nickel Cadmium) Battery

Advantages

- Very long life cycles
- Performs well in cold temperatures (to about 20 degrees Fahrenheit)
- Reasonably low self-discharge level
- No voltage drop at near-discharged levels

Disadvantages

- Very heavy battery
- Contains toxic metals and is environmentally unfriendly
- Does not function properly when consistently recharged before it fully discharges

NiMH (Nickel Metal Hydride) Battery

Advantages

- Lighter battery than NiCad, but heavier than Li-Ion
- Much higher energy density compared to equal size NiCad battery
- Contains no toxic metals or liquids

Disadvantages

- Poor performance in colder temperatures
- Relatively high self-discharge level
- Voltage drop at near-discharged levels
- Fewer life cycles (as compared to NiCad batteries)
- NiMH batteries generate significant heat during both charge and discharge cycles. In fact, temperature is one method used to determine end of charge.
- The NiMH pack cannot be charged when it is hot from being used. It must be cooled before charging since temperature is one factor used by the battery charger to determine when to shut off.

Sealed Lead Acid Battery

Advantages

- Inexpensive and simple to manufacture
- Mature, reliable, and well-understood technology
- Low self-discharge
- Capable of high discharge rates
- Long Service Life (between 200-1000 charge/discharge cycles)

Disadvantages

- Low energy density
- Environmentally unfriendly due to the lead content in the battery
- Transportation restrictions due to concerns regarding spillage in case of an accident
- Can be damaged if not charged after use

Li-Ion Polymer Battery

Advantages

- Very small and lightweight
- Improved safety/more resistant to overcharge
- Less chance for electrolyte leakage compared to Li-Ion battery

Disadvantages

- Very expensive
- Low energy density
- Decreased life cycle count compared to Li-Ion battery

After weighing the pros and cons of each battery type, it seems like sealed-lead acid batteries will be the path we take. Although they seem to be one of the largest types in terms of sheer size and weight,

sealed lead acid batteries are cheap and are very reliable. They also seem to hold their charge reasonably well and have a desirable life-cycle count.

Sensors

There are a wide range of vehicle sensor technologies available today. Each type of sensor has advantages and disadvantages. The following is a short list of some of the most common vehicle sensors.

Infrared (IR)

Two types exist: active and passive.

Active/Passive IR sensors

Active IR sensors transmit energy from an LED or laser diode. Passive IR detectors do not transmit energy; they only detect energy emitted by objects.

Advantages

- Active IR sensors can be used to capture data about the number of cars, presence, speed, and occupancy.
- If a laser diode is used, it is possible to capture data about the vehicle profile and shape.
- Passive IR sensors can be used to capture data about presence, occupancy, and count.
- One advantage for IR detectors is that they can be used in both day and night.

Disadvantages

- A disadvantage is that they are sensitive to weather conditions and ambient light.

Ultrasonic

Ultrasonic detectors are the one of the most common traffic sensors used in Japan. They are not widely used yet in the United States. Ultrasonic detectors work by transmitting ultrasonic energy and measuring the energy reflected by an object.

Advantages

- They can used to capture data about a vehicle's presence, speed, and occupancy.
- Ultrasonic detectors can be used in all weather conditions and do not need to be approved by the FCC.

Disadvantages

- A disadvantage is that they need to be mounted in such a way that it looks down on the vehicles and perpendicular to the vehicle.

Inductive Loops

This type of vehicle sensor is very common in the US. One or more loops of wire are embedded in the pavement and then connected to a control box. When a vehicle goes over the loop, the inductance of the loop goes down, which is read by the control box.

Advantages

- They can be used to capture data about a vehicles presence, speed, and occupancy.
- They are very reliable and very established in the US.

Disadvantages

- Every time a road is repaved, the detectors need to be replaced.
- They are also very sensitive in the installation process.

Microwave

They are most commonly used in Europe. Similar to ultrasonic detectors, microwave detectors also measure the amount of energy reflected from an object in its field of sensing.

Advantages

- They can be used to measure speed, occupancy, and presence.
- Some advantages include being a widely used technology by the military—making it a very “mature” technology, it can detect speed directly without any algorithms, and can detect multiple lanes of traffic at the same time.

Disadvantages

- A disadvantage is undesired vehicle detection due to multipath.

Piezoelectric

A piezoelectric sensor is made up of a long piezoelectric material inside a protective covering. When a car passes over the sensor, a voltage is produced, which is monitored and detected by a controller.

Advantages

- Can detect the exact time when a car passed over it.
- When combined with a second one, they can be used to measure a vehicle's speed.

Disadvantages

- for permanent installation, they must be installed in the pavement, and therefore would have to be replaced every time the road is repaved.
- Do not detect the presence of a stationary vehicle unless it is sitting directly on the sensor

Mode of Transmission

Another decision we need to make is what mode of transmission will best suit our needs. We need to make sure that our transmission will be reliable and function regardless of weather or other atmospheric conditions. Also, the transmitter will need to be able to transmit a significant distance in order to be effective. All these things will be taken into account as we look into types of transmission.

Bluetooth Transmission

Advantages

- Communicating devices can be positioned anywhere within the device's effective range
- Effective range may reach up to 100 meters
- Consumes small amounts of power

Disadvantages

- Because of the large range and radio frequency of Bluetooth, it is more susceptible to interference or interception
- Transmitting through physical objects greatly reduces the effective range of the device

Infrared Transmission

Advantages

- Very secure transmission due to its line-of-sight transmission
- Few or no international regulatory constraints

Disadvantages

- Requires a direct line of sight between communication devices
- Effective range is very short—usually around 10 meters

Radio Frequency Transmission

Advantages

- Very long effective range
- Relatively secure transmission due to thin frequency bands
- Unaffected by weather and/or atmospheric conditions

Disadvantages

- Multiple international regulatory constraints
- Consumes a significant amount of power

GPS Transmission

Advantages

- Very long range
- Secure and uninterrupted transmission

Disadvantages

- Obstructions limit the effectiveness of GPS transmission, especially in denser cities with more buildings
- Dependent on weather/atmospheric conditions to function properly and accurately

We discussed the advantages to each mode of transmission and decided that RF (radio frequency) transmission would be the best fit for our system. We chose this because RF transmission is not affected by weather conditions or physical obstructions. However, we may have to put a little more work into researching frequency bands that we are allowed to use because there are many international

restrictions that go along with radio frequency transmission. Nevertheless, we decided that it the advantages of RF outweigh the disadvantages and we are convinced that it will be the most efficient system for our purposes.

Microcontroller

For this project we need a microprocessor that can interface with a sensor and a radio transmitter, while being powered by a battery. The microprocessor does not need to have a very large number of I/O ports, as this project does not require many. We would also like to have a microprocessor that isn't very expensive in case we need to buy extras. Our first choice is the PIC18F4620, because we have used it previously in ECE 376. It is an inexpensive microcontroller that has plenty of I/O ports for our project's needs, and has plenty of software features to fit our needs. We also already have a whole board built around the PIC that was designed by Dr. Glower. This microprocessors features and our proven experience with it make this board a good choice for our project.

Microchip PIC18F4620

Advantages:

- Readily available
- Low cost
- Low power consumption
- Low power consumption in standby
- Built in timers and interrupts
- Plenty of I/O ports to support the project's needs

Disadvantages:

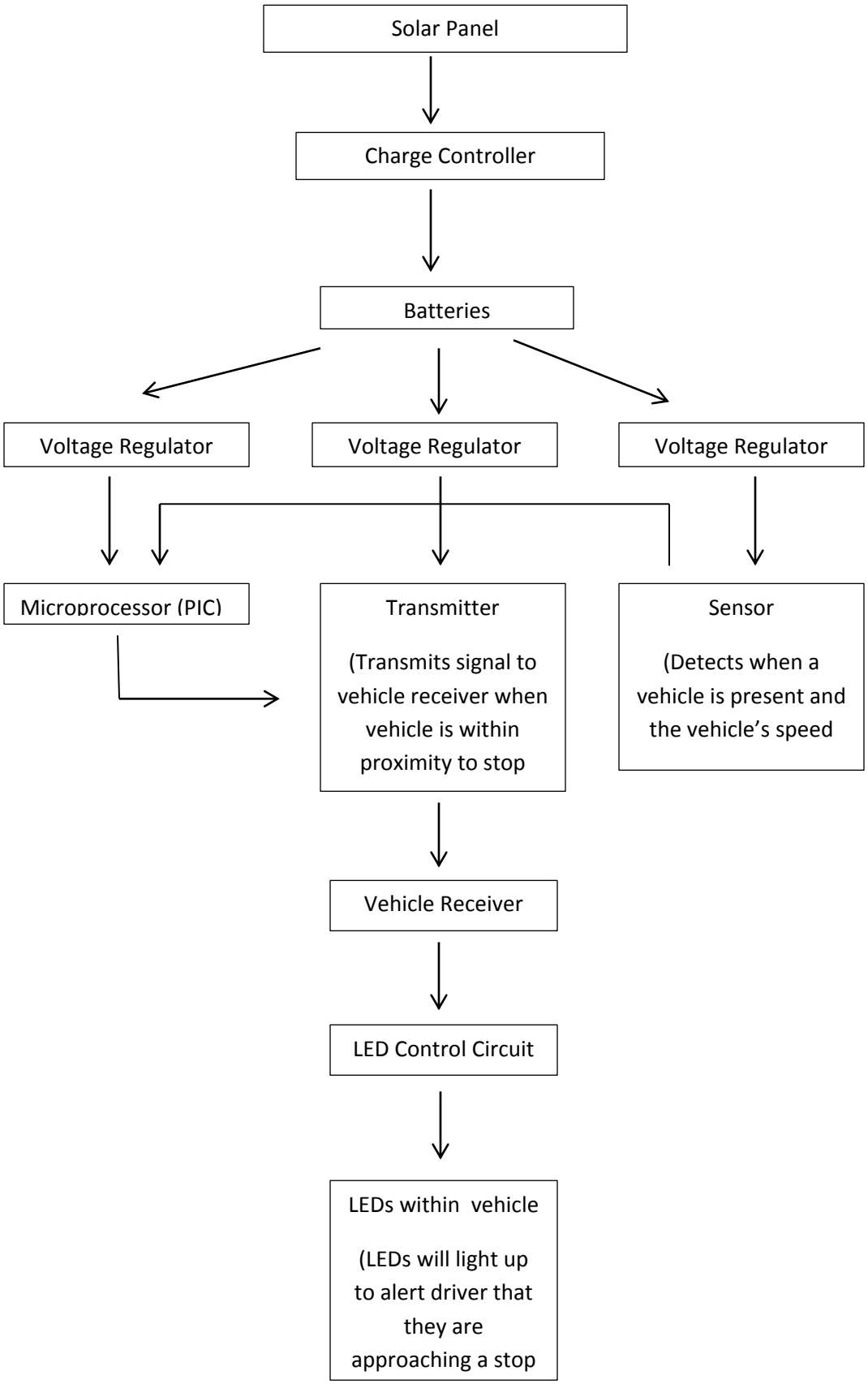
- Operating frequency isn't as fast as other microcontrollers available
- Low amount of program and data memory

Despite the disadvantages of the PIC microprocessor it will still be a viable choice for our project. If we decide in the future that the PIC does not have enough power to support our project, we will have to find a better microcontroller.

Budget				
Part	Cost Per Unit	Quantity	Total Cost	Notes
PIC 18F4620	$8.00	2	$16.00	
Solar Panel	$60.00	1	$16.00	Dr. Yuvarajan lent us a solar panel
Batteries	$50.00	1	$66.00	Depending on capacity this could be more
Charge Controller	$40.00	1	$106.00	
Voltage Regulators	$40.00	1	$146.00	
Sensor	$150.00	1	$296.00	
Transmitter	$50.00	1	$346.00	
Receiver	$50.00	1	$386.00	
LEDs for Stop Sign	$2.00	10	$436.00	
Enclosures for system components	$50.00	N/A	$486.00	
LEDs for car	$1.00	12	$498.00	
Misc. Hardware	$100.00		$598.00	Includes mounting material, sign material, post, brackets

Total Cost	**$598.00**

Block Diagram of our Novel Automobile Safety System



Project Timeline

Semester 1			
Task #	Task Description	Week	Who?
1	Requirements Capture Meeting	4	All
2	Requirements Capture Document:	5,6	All
3	>>Intro, Summary, Timeline/Gantt Chart	5,6	Zach
4	>>Previous Work	5,6	Jesse
5	>>Budget	5,6	Ian, Bo
6	>>Design Options Considered	5,6	All
7	Order Parts	7	All
8	Begin Programming PIC	8	Ian
9	Begin work with Voltage Regulators	8	Zach
10	Begin work with Transmitter and Receiver	8	Jesse, Bo
11	Interface w/ Sensor and PIC	9,10	Ian
12	Interface w/ Solar Panel and Batteries	9,10	Zach
13	Design of Transmitter and Receiver	9,10	Jesse, Bo
14	Breadboard PIC/sensor	11	Ian
15	Transmitter and Receiver Communication	11	Jesse, Bo
16	Interface Solar Panel/Batteries/Voltage Regulators	11	Zach
17	Progress Report: Prepare Individually and the Compile	12	All
18	Power Consumption and Power Requirements	13	Zach
19	Circuit Simulation in Multisim	14	Jesse, Bo
20	Progress with PIC Programming and interface	14	Ian
21	Start PCB layout in Ultiboard	15	Jesse, Bo
22	Interface Batteries/LEDs/PIC	15	Ian and Zach
23	Prepare for Presentation	15	All
24	Presentations	16	All

Semester 2			
Task #	Task Description	Week	Who?
1	Continue PCB Layout	2	Jesse, Bo
2	Interface Batteries/LEDs/PIC Cont.	2,3	Ian, Zach
3	Finish PCB Board	3,4	Jesse, Bo
4	EMC Testing	5,6	Jesse, Bo
5	Assemble Stop Sign with Post/Solar Panel/Sensor	4,5,6,7	All
6	Create Enclosures for System Components	8,9,10	All
7	Car LED Light Assembly	11,12	Ian, Zach
8	Transmitter/Receiver Troubleshooting in Car	11,12	Jesse, Bo
9	Connect System Enclosures to Stop Sign Assembly	13,14	All
10	Testing of final system assembly	15,16	All
11	Prepare for Presentation	17	All

Semester 1	
Reference	
Week 1	Aug. 20-25
Week 2	Aug. 27-Sept 1
Week 3	Sept. 2-8
Week 4	Sept. 9-15
Week 5	Sept. 16-22
Week 6	Sept. 23-29
Week 7	Sept. 30-Oct. 6
Week 8	Oct. 7-13
Week 9	Oct. 14-20
Week 10	Oct. 21-27
Week 11	Oct. 28-Nov. 3
Week 12	Nov. 4-10
Week 13	Nov. 11-17
Week 14	Nov. 18-24
Week 15	Nov. 25-Dec.1
Week 16	Dec. 2-8
Finals	Dec. 9-15

Semester 2	
Reference	
Week 1	Jan. 6-12
Week 2	Jan. 13-19
Week 3	Jan. 20-26
Week 4	Jan. 27- Feb. 2
Week 5	Feb. 3-9
Week 6	Feb. 10-16
Week 7	Feb. 17-23
Week 8	Feb. 24-Mar. 2
Week 9	Mar. 3-9
Week 10	Mar. 10-16
Week 11	Mar. 17-23
Week 12	Mar. 24-30
Week 13	Mar. 31-Apr. 6
Week 14	Apr. 7-13
Week 15	Apr. 14-20
Week 16	Apr. 21-27
Week 17	Apr. 28-May 4
Finals	May 5-11

Gantt Chart

Semester 1

Task #	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16
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Semester 2

Task #	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13	Week 14	Week 15	Week 16	Week 17
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Summary:

This design project will explore various topics including sensors and RF communications, and apply them to automobile safety. The system developed will use a sensor and RF communications to alert the driver of an automobile when they are approaching a stop sign. The goal of this system is to help improve passenger safety by alerting the driver when they are approaching a stop sign. The system will abide by all FCC regulations when added to existing vehicles. The project will have a low overall cost with a simple and economical design. In our project we will utilize a PIC processor/s, a RF transmitter and receiver, a long-range vehicle detection sensor, a sealed lead acid battery/batteries, and a solar panel to achieve our objectives. We are requesting a total budget of $598.00.